

Measurement of Speed of Sound in Carbon Dioxide with Cylindrical Resonator at Pressures up to 10 MPa

Xiao Juan Feng^{C, S}, Hong Lin, Zhao Wei Yin and Jin Tao Zhang
National Institute of Metrology (NIM), China, Heat Division, Beijing, China
fengxj@nim.ac.cn

Yuan Yuan Duan
Tsinghua University, Department of thermal engineering, Beijing, China

Carbon dioxide is one of the most important green-house gases. Accurate measurements of the thermophysical properties of carbon dioxide are crucial for the carbon capture and storage processes. Speed of sound measurements can reach an uncertainty less than 0.01% and have been used to calculate other thermophysical properties. The equation of state for carbon dioxide (Span and Wagner, in 1996) showed a 0.03% discrepancy with the most accurate speed of sound experimental data (Estrada-Alexanders and Trusler, in 1998). There are only two sets of speed of sound experimental data covered the gaseous region for carbon dioxide with the uncertainty of 0.5% and 0.005%~0.03%, respectively. We chose a different acoustic resonator to measure speed of sound in gaseous carbon dioxide. The cylindrical resonator was used in the measurement because NIM (National Institute of Metrology, China) developed fixed-path cylindrical resonator method to determine Boltzmann constant and quite a number of improvements and theoretical work have been done to reduce the uncertainty of this method. The speed of sound in carbon dioxide was measured using an oxygen-free copper cylindrical resonator with length of 80 mm and radius of 40 mm at temperature of (220 to 400) K and pressures up to 10 MPa. The uncertainties of the temperature, pressure measurement system and speed of sound were estimated to be no greater than ± 5 mK, $\pm 0.005\%$ and $\pm 0.01\%$. The measured speed of sound was compared with the results using different methods. The acoustic virial coefficients and ideal-gas specific heat capacity were also calculated.